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TITLE: Developing the experts we need: Using ScholarRX/USMLE-Rx test questions to support the development of adaptive expertise

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TITLE OF PROPOSED PROJECT: Developing the experts we need: Using ScholarRX/USMLE-Rx test questions to support the development of adaptive expertise

TYPE OF SCHOLARLY PROJECT: Educational Research

SCHOLARRx/USMLE-Rx COMPONENTS UTILIZED: Scholar Rx curriculum bricks, USMLE-Rx Qmax questions

Research Question:

Does the sequencing of test-question difficulty during learning impact student performance on measures of preparation for future learning?

Specific aims:

1. Assess the utility of the ScholarRx/USMLE-Rx platform in supporting the development of a key capability of adaptive expertise
2. To determine whether manipulating the order of test-questions during instruction can enhance the ability of students to learn a different but related concept.

Abstract:

Rationale and research question: Giving learners the opportunity to individualize test questions within the ScholarRx/USMLE-Rx platform has the potential to be a powerful learning experience. The aim of this research is to determine whether the sequencing of test-questions according to level of difficulty during an initial learning phase (using USMLE-Rx Qmax questions) would positively or negatively affect student performance on measures of future learning.

Methods: Participants will be randomly assigned to either a "hard-easy" learning condition or "easy-hard" learning condition and asked to complete a series of USMLE-Rx Qmax pharmacology questions. All participants will then complete a 'practice' phase where they will be tested on the same content (pharmacology). After the practice phase, all participants will complete a 'new learning' phase using Scholar Rx curriculum bricks selected from a new, but related area of content (example: endocrinology). Following the new learning phase participants will complete an assessment phase composed of USMLE-Rx Q-max questions at the medium level of difficulty. For each participant, we will calculate the proportion of correct responses on the practice phase, and the 'future learning assessment' phase as outcome measures.

Anticipated outcome: We hypothesize that participants in both groups will perform the same on the practice phase; however, the participants who are randomized to the "hard-easy" learning condition will outperform those in the "easy-hard" learning condition during the 'future learning assessment' phase.

BACKGROUND/RATIONALE:

Giving learners the opportunity to individualize test questions within the ScholarRx/USMLE-Rx platform has the potential to be a powerful learning experience. While most learners use test questions for self-assessment, answering ScholarRx/USMLE-Rx test items might also enhance memory for the material through a phenomenon known as *test-enhanced learning* (Gates, 1917). A robust literature in education and cognitive psychology has demonstrated that taking tests improves retention of knowledge and skills across a variety of content areas (Roediger & Karpicke, 2006). The ScholarRX/USMLE-Rx platform allows students to test themselves using high-quality items, suggesting that it is a valuable tool for test-enhanced learning.

To date, the majority of the research on test-enhanced learning has used performance of learners on the final assessment of memory retention as the primary outcome measure (Larsen, Butler, & Roediger, 2008), confirming a role for ScholarRx/USMLE-Rx in supporting the short-term learning goals of most students. However, instructional strategies that maximize performance in the short term may not be the ones that maximize learning in the longer term (Schmidt & Bjork, 1992; Schwartz & Martin, 2004). Little is known about the potential of test-enhanced learning to support performance on measures related to knowledge transfer and future learning (Kapur & Bielaczyc, 2012). This is a critical gap in the literature because the capacity to learn new information in the future is necessary for the development of adaptive expertise and has been described as a key competency for health professions education (Mylopoulos, Brydges, Woods, Manzone, & Schwartz, 2016). The use of instructional tools that leverage test enhanced-learning, like ScholarRx/USMLE-Rx, to support adaptive expertise remains largely unexplored.

Our proposed study aims to utilize the ScholarRx/USMLE-Rx platform to maximize the benefits of test-enhanced learning and support the development of adaptive expertise. The platform allows learners to choose the level of difficulty of the test questions (easy, medium, or hard). While the natural tendency of most learners is to master easier questions before proceeding to more difficult questions, this may not be the best way to learn if the goal is to optimize the development of adaptive expertise. In particular, research has shown that when learners are encouraged to productively struggle with complex problems that are beyond their abilities, they may not generate a solution in the short term; however, the struggle may activate relevant prior knowledge which can improve conceptual understanding and support future learning (Carpenter, 2012; Kapur, 2014; Mylopoulos & Woods, 2014; Schwartz, Chase, Oppezzo, & Chin, 2011; Steenhof, Woods, van Gerven, & Mylopoulos, 2018). Thus, it can be argued that the ScholarRx/USMLE-Rx platform could enhance student development of adaptive expertise by optimizing the test-enhanced learning effect through manipulation of the sequence of test questions.

METHODOLOGY

Participants: With institutional ethics approval, we will aim to recruit 100 participants. The proposed participants are PharmD students enrolled in the Leslie Dan Faculty of Pharmacy at the University of Toronto. The Faculty of Pharmacy has approximately 240 students enrolled in each year of study. This experiment would target participants from the first and second year of the program which would yield a pool of approximately 480 participants. This is consistent with the numbers of participants in previous studies conducted by our research team at the Faculty of Pharmacy which have yielded response rates of approximately 20%, consequently we anticipate being able to recruit approximately 100 participants. Participants will be offered gift certificates in the amount of $35.00 CAD as compensation for an estimated 2 hours of their time.

***ScholarRx/USMLE-Rx components*:** This study will utilize both ScholarRx curriculum bricks and the USMLE-Rx Qmax Questions. The order of USMLE-Rx Qmax questions will be manipulated based on the level of difficulty (as described in the study design). The practice phase and new learning phase will be composed of pharmacology questions. The similar, but related content, will be a specific area of study (for example: endocrinology).

***Basic evaluation/study design*:**

Participants will be randomly assigned to either the "hard-easy" learning condition or "easy-hard" learning condition

Learning phase: Participants (N=100) will first complete a learning phase which will be comprised of USMLE-Rx Qmax questions from one domain (example: pharmacology). This is categorized as a learning phase, because regardless of whether the participant chooses the correct or incorrect answer, the correct answer and the rationale will be presented to the learner after they choose their answer and students will have the opportunity to learn from their successes and mistakes.

The questions will be selected from either the "easy" or "hard" levels of difficulty of the USMLE-Rx Qmax question bank. The difference between the conditions is that participants who are randomized to the "hard-easy" condition (n=50) will be presented with the hard questions first, followed by the easy questions. The learners in the "easy-hard" condition (n=50) will be presented with the questions in the reverse order. This phase will be comprised of 30 questions – 15 easy questions, and 15 hard questions. The questions will be the same for both groups. The learning phase will take approximately 50 minutes.

Practice phase: All participants (N=100) will then complete a practise phase where they will be presented with 15 "medium" difficulty USMLE-Rx Qmax questions. The questions will be the same for both groups and the content area (pharmacology) will be the same as in the learning phase. This practice phase will serve as a check for recall of content. The expectation is that participants, regardless of which condition they were randomized to, will perform the same on these questions. Participants will be allotted 20 minutes for the practice phase.

New learning phase: All participants (N=100) will then receive instruction through curriculum bricks on a different, but related, curriculum brick. For example, endocrinology. Participants will be allotted 20 minutes for this phase.

Future learning assessment phase: Finally, all participants (N=100) will complete a future learning assessment phase composed of USMLE-Rx Q-max questions for the subject that was taught in the 'new learning' phase. The participants will be presented with 30 questions. These questions will be at the medium level of difficultly. Participants will be allotted 30 minutes for this phase.

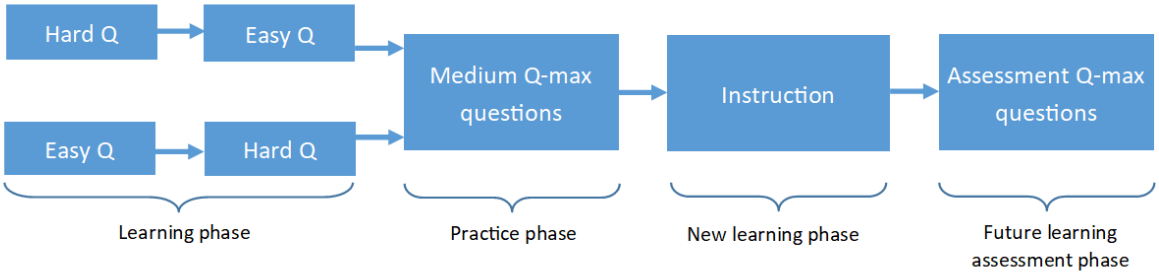

Figure 1: Methodology

Analysis:

For each participant, we will calculate the proportion of correct responses on the practice phase and the future learning assessment as outcomes measures.

To address the research question, the scores on the future learning assessment will be submitted to ANCOVA, using learning condition ("easy-hard" versus "hard-easy") as a between-subject variable and covariates of performance on the practice phase questions.

The data on the practice phase will be submitted to an independent t-test, comparing the "easy-hard" and "hard-easy" conditions. This analysis is secondary, intended only to ensure that both groups were able to comprehend the material. Based on the existing literature, we do not anticipate a significant difference between groups on the practice phase.

Anticipated outcomes/impact

We hypothesize that the participants randomised to the "hard-easy" condition will outperform those participants randomised to the "easy-hard" condition. This is predicated on the results of other education studies on test-enhanced learning and productive failure (Kapur, 2014; Steenhof et al., 2018). Based on previous work in productive failure studies, we anticipant the participants will perform the same on the first practice phase.

The results of this study will advance our knowledge in the areas of health professions education, test-enhanced learning, and adaptive expertise.

Once the study is complete and the results are analysed, the research team will write up the results to be published in a reputable, peer-reviewed journal. The team would also plan to present the results of the research at an international scientific conference. For example: An International Association for Medical Education (AMEE) conference, American Educational Research Association (AERA) Conference, or the Association of Faculties of Pharmacy of Canada (AFPC) conference.